A PILOT STUDY ASSESSING ENERGY EXPENDITURE DURING INTERACTIVE VIDEO GAME PLAY

Brittany Elizabeth Yates

A thesis submitted to the faculty of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Master of Arts in the Department of Exercise and Sport Science (Exercise Physiology).

Chapel Hill
2008

Approved by:

Robert McMurray, PhD

Lauren M. Mangili, MEd

Edgar Shields, PhD

ABSTRACT

BRITTANY ELIZABETH YATES: A Pilot Study Assessing Energy Expenditure during Interactive Video Game Play.
(Under the direction of Robert G. McMurray, Ph.D.)

This study investigated the physiological responses to participation in two modes, Cardio (CV) and Weight Loss (WL), of "Yourself!Fitness™." Particularly, differences in the game-predicted and measured caloric expenditure for both the CV and WL modes were examined. Additional comparisons were made for the amount of time spent at or above the ACSM recommended VO_2max and HRmax. 15 healthy volunteers (7M/8F) aged 18-24, participated in two 30 minute interactive video game exercise sessions, CV and WL. There were no differences in HR, VO_2, or measured energy expenditure between the CV or WL trials ($p>0.051$). No differences in time spent above the ACSM threshold for either VO_2 or HR between the CV or WL trials existed ($p>0.169$). Measured energy expenditure for the CV and WL exercise sessions was under-predicted by 88-97 kcals. Yourself!Fitness™ has the potential for cardiorespiratory benefit if the exercise session is extended to 60 minutes.

ACKNOWLEDGEMENTS

I would like to take this opportunity to extend my heartfelt gratitude and deepest appreciation to all who were involved in the completion of this document. First, I would like to thank my advisor, Dr. Robert G. McMurray, for his patience, sound advice, and expertise. I would also like to thank my committee members, Ms. Lauren M. Mangili and Dr. Edgar W. Shields whose knowledge, encouragement, and attention to detail I could not have done without. I would not be the young lady I am today without the unfailing love and continued support of my parents, family, friends, and Caton. Thanks to Dr. Claudio L. Battaglini, Dr. Anthony C. Hackney, and Dr. Bonita L. Marks for sharing wisdom in their respective fields and enriching my graduate experience at the University of North Carolina at Chapel Hill.

There were also many silent observers who were integral in the maintenance of my sanity and motivation to keep pushing forward. I would like to thank Reginald S. Hinton, Jr. and other Carolina Campus Recreation staff for their continued moral support and guidance. Thanks to my fellow graduate students who have shared in the experiences of these past two years. I would also like to thank to the Young Adult Ministry and congregation of Orange United Methodist Church for their inspiration and spiritual support. Last, but certainly not least, thanks be to God, with whom all things are possible.

"The difficulties and struggles of today are but the price we must pay for the accomplishments and victories of tomorrow." - William J.H. Boetcker

TABLE OF CONTENTS

LIST OF TABLES vii

LIST OF FIGURES viii

LIST OF ABBREVIATIONS ix

CHAPTER

I. INTRODUCTION 1

Statement of Purpose 2

Statement of Hypotheses 3

Delimitations 3

Limitations 4

Definition of Terms 4

Significance of the Problem 5

II. REVIEW OF LITERATURE 6

American College of Sports Medicine Guidelines 6

Physical Inactivity 7

Video Game Industry 7

Obesity 8

Interactive Video Games 8

Previous research on Metabolic Responses to Video Games 10

Yourself!Fitness™ 13

Summary 14
III. METHODOLOGY 15
Subjects 15
Instrumentation 15
Procedures 16
Data Management 20
IV. RESULTS 22
Subject Characteristics 22
Physiological Responses 22
ACSM Guidelines 23
Energy Expenditure 24
V. DISCUSSION 26
"Cardio" versus "Weight Loss" Exercise Sessions 26
Exercise Intensity and Duration 27
Predicted versus Measured Energy Expenditure 28
Potential Impact 29
Strengths and Weaknesses of the Video Game 29
Limitations 30
Conclusions 31
Recommendations 33
LIST OF APPENDICES 34
REFERENCES 47

LIST OF TABLES

TABLE

1. Oxygen uptake (VO_2) and heart rate (HR) responses during exercise sessions 23

LIST OF FIGURES

FIGURE

1. Means ± SD for number of minutes spent above ACSM threshold for cardiorespiratory fitness comparing the cardio (CV) and weight loss (WL) exercise sessions. VO_2=oxygen uptake; HR=heart rate.....24
2. Subject-by-subject predicted and measured energy expenditures for the cardio (CV) and weight loss (WL) exercise sessions.....25

LIST OF ABBREVIATIONS

ACSM	American College of Sports Medicine
CV	"Cardio" exercise session
HR	Heart rate
Kcal	Kilocalorie
RER	Respiratory exchange ratio
RPE	Rating of perceived exertion
VO_2	Oxygen uptake
WL	"Weight Loss" exercise session

CHAPTER I

INTRODUCTION

The incidence of obesity-associated chronic diseases, such as type II diabetes and cardiovascular disease are increasing in adults. At the same time, adults are decreasing participation in organized and spontaneous moderate-intensity physical activity (35). A study conducted by the National Institute of Health Sciences (NIHS) between 1999 and 2001, confirmed that 62% of adults, 18 years of age and older, never engaged in any vigorous leisure-time physical activity lasting 10 minutes or longer per week (28).

It has been suggested that moderate-to-high intensity physical activity is being replaced by sedentary pastimes such as television viewing, surfing the internet, or playing video games (10, 13, 14, and 31). Nielsen Wireless and Interactive Services recently conducted a study indicating approximately 45.7 million homes have video gaming consoles in the United States alone; and that in any given minute, approximately 1.6 million people in the United States, aged two and older, are using a video game console (5). These startling statistics are compounded by the fact that video game sales, including software, hardware, and accessories, grossed over $17.9 billion in 2007 alone (24).

Lanningham-Foster et al. (2006) suggest that activity-promoting video game and computer use is one potential approach for limiting the amount of time spent performing sedentary activities (14). Yourself!Fitness™, produced by responDESIGN, for the PlayStation®2 gaming console is one such video game. Maya, the Yourself!Fitness™ virtual

personal trainer, leads participants through an interactive, unique, and customized fitness program designed to achieve their fitness goals (3).

The makers of Yourself!Fitness™ claim to have produced a fully customizable fitness plan that contains over 500 different exercises to help participants focus on everything from cardiovascular health and weight loss to muscular strength and flexibility. The game uses video to demonstrate concepts and techniques, and computer power to organize programs and monitor progress toward personal fitness goals. By tracking participant effort, through perceived level of exertion ratings, the virtual personal trainer is able to alter the course and difficulty of a workout as it progresses to match the participants' personal needs for the day. Yourself!Fitness™ is supposed to be a versatile video game, aimed at meeting the fitness needs of both previously sedentary and active individuals alike, however, these claims have never been tested. The knowledge gained through research using Yourself!Fitness™ will help exercise physiologists determine if game play can be a viable means for physical activity.

STATEMENT OF PURPOSE

The purpose of this investigation was to determine the physiological responses to participation in two modes, Cardio and Weight Loss, of "Yourself!Fitness™." Of particular interest, this study investigated differences in the manufacturer's game-predicted and measured caloric expenditure for both the Cardio and Weight Loss modes. Additional comparisons were made for caloric expenditure between the Cardio and Weight Loss modes and the amount of time spent at or above the ACSM recommended VO_2max and HRmax.

STATEMENT OF HYPOTHESES

Hypothesis 1: There will be no statistically significant difference in oxygen uptake (VO_2) between the Cardio and Weight Loss modes.

Hypothesis 2: There will be no statistically significant difference in heart rate between the Cardio and Weight Loss gaming modes.

Hypothesis 3: There will be no statistically significant difference between the amount of time spent above the ACSM threshold for aerobic training (greater than 40% VO_2max or 55% HRmax) between the Cardio and Weight Loss modes.

Hypothesis 4: There will be no relationship between the game-predicted and measured energy expended, in kilocalories (kcals), for the duration of the Cardio mode.

Hypothesis 5: There will be no relationship between the game-predicted and measured energy expended, in kcals, for the duration of the Weight Loss mode.

Hypothesis 6: There will be no statistically significant difference in the measured energy expended, in kcals, between the Cardio and Weight Loss modes.

DELIMITATIONS

1. Participants were healthy, college-aged males and females.
2. Participants exercised at the same time of day for each of their sessions.
3. Participants were required to have a minimum of 24 hours rest between sessions.
4. The workout was 30 minutes in length including a 3 minute warm-up and 2 minute cool-down.
5. All participants were requested to eat the same meal 4 hours before the two experimental sessions.
6. Participants completed all trials within 2 weeks of enrolling in the study.

LIMITATIONS

1. It was assumed that participants performed to their true maximum capacity during the maximum capacity (VO_2max) test on the treadmill.
2. The results were limited to young adult men and women.
3. Kilocalories were determined from measurements of oxygen (O_2) uptake and carbon dioxide (CO_2) output and not directly determined.
4. Only sedentary individuals may improve cardiovascular fitness at the ACSM recommended 40% VO_2max or 55% HRmax.

DEFINITION OF TERMS

1. *Maximal Oxygen Uptake (VO_2max)*: the greatest amount of oxygen the body can take and utilize in the cells to produce ATP for energy needs. VO_2max is expressed in liters per minute (L/min) or milliliters per kilogram of body weight per minute (mL/kg/min). The attainment of VO_2max is determined when two or more of the following criteria are met: 1) a 150 mL/min or less increase, leveling-off, or decrease in VO_2 in response to an increased workload; 2) a blood lactate level > 10 mmol/L; 3) a heart rate at the age-predicted maximum [within 5-10 bpm]; 4) a respiratory exchange ratio (RER) ≥ 1.1; or 5) a rating of perceived exertion (RPE) > 18 (15).
2. *PlayStation® 2*: Electronic video-gaming console.
3. *Personal Profile*: Participants will be guided through a series of strength and flexibility tests using Yourself!Fitness™. These results will help to compile a personalized health and fitness program.

SIGNIFICANCE OF THE PROBLEM

With obesity on the rise, it seems of paramount importance to explore other venues for promoting physical exercise. Sitting in front of a television, computer screen, or video game are very popular sedentary activities many people encounter on a daily basis. In an effort to combat the time spent participating in these activities, several physical activity-promoting video games have been created (7, 14). It is important to determine whether these activities result in increased energy expenditure (14). If these activity-promoting games increase energy expenditure only minimally, then their applicability for reversing sedentary lifestyles would be limited and offer false promise (14). Conversely, if energy expenditure is substantially increased during participation in these video games, they could become potent tools for reversing sedentary behaviors while permitting highly valued screen-based activities (14). It has not yet been determined, whether Yourself!Fitness™ is effective in increasing energy expenditure equivalent to moderate and/or vigorous intensity physical activity.

CHAPTER II

REVIEW OF LITERATURE

With the continuing affordability in advanced technology, interactive video games are beginning to replace the more popular sedentary video games that currently saturate the market. Yourself!Fitness™ (responDESIGN, Portland, OR) is a popular interactive video game that, according to the makers, has the potential improve physical fitness. The following review will examine the recommendations for achieving cardiorespiratory fitness as well as the contributions of physical inactivity and the video game industry to the increase in obesity. A discussion is also provided on the types of interactive video games available in today's market, the scientific research that has been conducted on these games, and their potential to supplement and/or replace current physical activity regimens.

AMERICAN COLLEGE OF SPORTS MEDICINE GUIDELINES

Based on the existing evidence concerning exercise prescription for healthy adults and the need for guidelines, the American College of Sports Medicine (ACSM) developed a position stand on the recommendations for the quantity and quality of training for developing and maintaining cardiorespiratory fitness in the healthy adult (29). Exercise prescription is based upon the frequency, intensity, and duration of training, the mode of activity, and the initial level of fitness (29). Every adult in the United States should accumulate 30 minutes or more of moderate-intensity cardiovascular exercise on at least three, preferably five, days per week (26). Each exercise bout should be performed at an intensity of 55/65%-90% of

maximum heart rate (HRmax) or 40/50%-85% of maximum oxygen uptake (VO_2max) and last 20-60 minutes in duration (29).

PHYSICAL INACTIVITY

The formation of the ACSM guidelines has benefited many Americans; however, there are still many more who continue in their sedentary ways adding to the ever-growing population of overweight and obese individuals. Only about 15% of adults in the United States participate in physical activities with sufficient intensity and regularity to meet minimum ACSM recommendations for the improvement or maintenance of cardiorespiratory fitness (35).

There is extensive literature indicating that physical inactivity is associated with an increased incidence of cardiovascular disease, obesity, stroke, hypertension, type II diabetes, certain cancers, osteoporosis, and several psychological disorders (23, 37). Despite this information, most Americans have little or no physical activity in their daily lives (19, 37). As of 2007, 62% of adults (57% of men and 66% of women), 18 years of age and older, never engaged in any periods of vigorous leisure-time physical activity lasting 10 minutes or more per week; while only 24% engaged in such activity three or more times per week (28). Fewer than half of the adult population in the United States (49.7% of men and 46.7% of women) meets the minimum guidelines for physical activity (4).

VIDEO GAME INDUSTRY

The decline in regular physical activity and recent increase in sales of video games suggests that time spent playing these games has also increased (32). In 2007, over $17 billion were spent on video game software and hardware, most of which are sedentary in nature (24). The Nielsen Company estimated that in 2006, there were 45.7 million

households in the United States with video game consoles (5). During that same time period, 148.4 million persons, aged two and older, had access to at least one video game console system in their home (5). It has also been estimated that 93.8 million video game console users, age two and older, play video games for an average of 2 hours and 15 minutes per day (5). The average video game player is 33 years old, with 44% of gamers falling between the ages of 18 and 49 (9). Thirty eight percent of all video game players are women (9). Even with the millions of individuals playing video games for several hours a day, 79% of video game players of all ages report exercising or playing sports an average of 40 minutes per day (9).

OBESITY

The incidence of obesity and overweight is increasing in adults and children throughout the world. According to the Centers for Disease Control and Prevention (CDC), 35% of adults were overweight and 26% were obese based on estimates of body mass index conducted in 2006 (28). Current lifestyles and environments might discourage regular participation in physical activity (16). Many researchers believe obesity can be attributed, in part, to the high prevalence of television and video game activities (37). The displacement of sports and other physical activities by television and video games may contribute to reduced physical activity, which will further lead to increased overweight and obesity (32).

INTERACTIVE VIDEO GAMES

Historically, video games have been identified as the culprit of physical inactivity; however, the introduction of interactive video games has been shown to increase energy expenditure. Video game industries are beginning to design video games that incorporate exercise, as opposed to the sedentary style game that many individuals are familiar with. The

combination of exercise with video game is rapidly becoming known as "exergaming" (16, 25).

Several activity-promoting video games directed at children and adolescents exist and have the ability to promote physical activity during screen time (14). These interactive, physically stimulating video games have the potential to become a powerful tool in combating obesity. Interactive video games that use physical activity to control game play include: Dance Dance Revolution™ (Konami Digital Entertainment, Tokyo, Japan), EyeToy® (Sony Computer Entertainment, Foster City, CA), GameBike™ (CateEye Electronics Ltd., Boulder, CO), and the Wii™ (Nintendo of America, Inc., Redmond, WA).

Konami released Dance Dance Revolution™ in 1998, and it rapidly became a cult phenomenon as players embraced the physically immersive dance experience (33, 34). This dance simulation game involves one or two dancer-players who follow a sequence of arrows on the screen by stepping on a foot switch panel, in time with the music. The arrow combinations and cadence on the video screen determine the level of difficulty (34). As the tempo of the songs increase, the amount of movement, coordination, and energy expenditure required also increases (33, 34). Another approach to interactive video games is through the use of the gaming camera, EyeToy®, that plugs into a PlayStation® 2 (Sony Computer Entertainment, Foster City, CA) console's Universal Serial Bus (USB) port and lets players control games by tracking their upper- and lower-body movements. Players see a mirror image of themselves on the screen as they interact with virtual characters and backgrounds, contributing to increased physical activity (33). Cateye's GameBike™ stationary bicycle has rotation sensors connected to the handlebar and pedals. These sensors let players control games by pedaling and steering. The GameBike™ is ideal for playing racing games because

the sensors record speed and changes in direction (33). The Wii™ is a popular game system from Nintendo® that uses a wireless controller about the size of a television remote to sense the player's motions for a variety of games. For instance, in a tennis game you swing the controller like a racket; for golf, the controller becomes your club (1, 21). Nintendo® has also announced the development of a pressure-sensitive balance board for the Wii™ that would be used for extensive array of fun and dynamic activities, including aerobics and yoga (21). Thus, there are several approaches to interactive video gaming.

PREVIOUS RESEARCH ON METABOLIC RESPONSES TO VIDEO GAMES

Segal and Dietz (1991) have reported playing the standing video game Ms. Pac Man (Midway Games, Chicago, IL), increases metabolic rate approximately 80% above rest (32). They assessed the metabolic and cardiovascular responses to video game play in 32 males and females aged 16 to 25 years. Heart rate, blood pressure, and oxygen consumption (VO_2) were measured consecutively over 30 minutes. Playing the video game significantly increased heart rate, systolic and diastolic blood pressure, and oxygen consumption. Energy expenditure increased from 6.08 ± 0.24 kJ/min while the subjects stood inactive to 10.94 ± 0.49 kJ/min while they played the video game. The increase in metabolic rate and cardiovascular stimulation was similar in magnitude to walking 2.0 miles per hour. Although increases in energy expenditure were seen in this study, playing Ms. Pac Man may not provide sufficient cardiorespiratory stress to improve physical fitness (32).

In 2006, Lanningham-Foster et al., conducted a research study on the energy expenditure of sedentary screen time compared with active screen time for 25 children aged 8 to 12 years (14). In this study, watching television and playing video games while seated increased energy expenditure by 20 ± 13% and 22 ± 12% above resting values, respectively.

For the activity-promoting video games, energy expenditure increased by 108 ± 40% with the EyeToy® and by 172 ± 68% with Dance Dance Revolution® Ultramix 2. Walking on the treadmill while watching TV increased energy expenditure 138 ± 40% over resting values. Researchers concluded energy expenditure more than doubles when sedentary screen time is converted to active screen time (14).

Similarly, Warburton et al. (2007) evaluated the effectiveness of the GameBike™ on health-related physical fitness and exercise adherence in comparison with stationary cycling alone in 14 college-aged males (37). They found that interactive video game training leads to significant improvements in several markers of health status. GameBike™ participants also attended exercise sessions 30% more frequently than those in the stationary cycling group. The interactive video game training program resulted in significantly greater changes in VO_2max and musculoskeletal fitness than those observed after traditional cycle exercise training in college-aged males who were provided the choice to exercise (37).

Maddison et al. (2007) also compared energy expenditure between active and non-active video games in 21 children ages 10-14 years old. The active video games expended significantly more energy (range = 2.9 ± 0.7 kcal/min to 6.5 ± 1.7 kcal/min) compared with rest (1.3 ± 0.2 kcal/min) and non-active video games (1.6 ± 0.2 kcal/min) (16). Energy expenditure while playing the active video games is similar in intensity to light to moderate traditional physical activities such as walking, skipping, and jogging (16).

Tan et al. (2002) assessed the intensity and energy cost of a dance simulation game (Dance Dance Revolution™) in 21 males and 19 females age 17.5 ± 0.7 years (34). Heart rate and VO_2 were measured during a maximal treadmill exercise and during a dance simulation game at a self-selected intensity. Participants had an average heart rate of 137 ±

22 beats per minute and a VO_2 of 24.6 ± 4.7 ml/kg/min, which corresponds to an intensity of 70% of HRmax, 53% heart rate reserve (HRR), and 44% VO_2max. The percent HRmax and HRR just meets the minimum American College of Sports Medicine (ACSM) guidelines for aerobic training; however, the percent VO_2max does not (34).

In a study of 22 children and adolescents, Unnithan et al. (2006) also compared the physiological responses of playing Dance Dance Revolution™ to the ACSM recommendations for developing and maintaining cardiorespiratory fitness (36). Cardiorespiratory measurements were taken both during a maximal treadmill walking test and during a 12-minute Dance Dance Revolution™ protocol. Measures of heart rate indicated participants were above the minimal ACSM heart rate intensity for developing and maintaining cardiorespiratory fitness when participating in the Dance Revolution™ protocol. The VO_2 reserve, however, did not meet ACSM standards for developing and maintaining cardiorespiratory fitness (36).

Norlin et al. (2007) examined oxygen uptake, heart rate, and rating of perceived exertion during three levels of Dance Dance Revolution™ in 24 volunteers between 12 and 25 years of age (22). Oxygen uptake was on average 18.8 ± 4.7, 20.2 ± 4.6, and 25.1 ± 5.6 mL/kg/min (42 ± 13, 45 ± 13, and 56 ± 15% VO_2max) for the light, standard, and difficult modes of Dance Dance Revolution™. Heart rate was on average 118 ± 12, 127 ± 14, and 143 ± 16 beats per minute (63 ± 7, 68 ± 9, 76 ± 10% HRmax) for the light, standard, and difficult modes of Dance Dance Revolution™. Therefore, the standard and difficult modes of Dance Revolution™ elicit VO_2 and heart rate responses that meet the ACSM recommendations for improving cardiorespiratory endurance (1, 22).

YOURSELF!FITNESS™

Unlike traditional VCR and DVD workouts, which feature humans, Yourself!Fitness™ offers a virtual personal trainer that can modify a participant's workout from day to day (12, 38). Yourself!Fitness™ targets regular exercisers who want new options; specifically, women, whom the video game industry has largely ignored, and couch potatoes who haven't heeded more traditional calls to get up and move (12).

Routines never get stale with more than 500 different exercises; including yoga and Pilates. Each exercise has a tutorial included, along with the ability to control the on-screen camera so all angles of the exercise can be seen (27). Exercises can even be altered to incorporate exercise equipment such as free weights, step benches, and exercise balls (6). As an added bonus, Yourself!Fitness™ also comes with a customized meal-planning component, that offers more than 4,500 recipes (2). With over five thousand members, the Yourself!Fitness™ forum, is home to many praises and weight loss success stories (38).

Maya, the interactive, virtual personal trainer, uses the physical profile to help participants choose their desired fitness goals and then achieve them (30). Flexible settings, frequent positive reinforcement, and other incentives will also keep participants motivated. The music and workout environment can be changed to fit the mood of participants. Adjustments can also be made to the level of difficulty throughout the workout to meet participants' needs (30).

While Yourself!Fitness™ is not able to replace a gym facility or human personal trainer, the video game may be able to reach a population that is notorious for its sedentary ways. Fitness professionals, however, suggest game-based fitness programs are best when

used as a supplement for a well-rounded, individualized routine that incorporates both cardiovascular exercises and strength training, whether in-home or at the gym (12).

SUMMARY

Little scientific research has been conducted on the effects of interactive video games on energy expenditure. Existing research shows promise that energy expended during interactive video game play could be sufficient enough to supplement or replace a regular physical activity routine. Given the mass appeal of video games, it stands to reason that this form of physical training may be useful in the battle against physical inactivity and associated health complications. Therefore, interactive video games should be explored further to determine the physiological benefits.

It is the goal of the current investigation to determine if participation in two modes, Cardio and Weight Loss, of "Yourself!Fitness™" will elicit physiological responses equivalent to participation in moderate to vigorous intensity physical activity. Of particular interest, this study will examine the differences in the manufacturer's game-predicted and measured caloric expenditure for both the Cardio and Weight Loss gaming modes. Additional comparisons will be made for caloric expenditure between the Cardio and Weight Loss modes and the amount of time spent at or above the ACSM recommended VO_2max and HRmax.

CHAPTER III

METHODOLOGY

SUBJECTS

This study was conducted in the Applied Physiology Laboratory at the University of North Carolina at Chapel Hill. The subjects consisted of 15 healthy volunteers (7 men and 8 women) aged 18-24 years. Previous training was not required for participation in this study; however, subjects must have been able to complete 30 minutes of moderate intensity exercise.

INSTRUMENTATION

All data were collected in the Applied Physiology Laboratory, located in Fetzer Gymnasium, at the University of North Carolina at Chapel Hill. The following instruments were used to collect and analyze the data for this study according to standard laboratory procedures:

During the initial assessment height was measured using a P. E. Stadiometer (Vital Signs, Graysville, WI), while weight was assessed using a Detecto Scale (Webb City, MO). Subjects then completed a graded exercise test to measure maximum oxygen uptake (VO_2max). This test was performed on a Quinton treadmill, (Bothell, WA). The treadmill was calibrated prior to each test to ensure accuracy of speed and grade. Oxygen uptake (VO_2) during the graded exercise test was measured using the ParvoMedics metabolic

measurement system (Sandy, UT). Cardiac function during the graded exercise test was measured using the Schiller EKG (Baar, Switzerland).

During the exercise trials, oxygen uptake (VO_2) was measured using the Cosmed $K4b^2$ system (Rome, Italy). Several studies have concluded the Cosmed $K4b^2$ is an accurate (11, 18), valid (11, 18), and reliable (8) means of assessing energy expenditure. Heart rate was monitored using a Polar Heart Rate Monitor (Lake Success, NY). Participants followed the on-screen personal trainer, Maya, during both the Cardio and Weight Loss exercise sessions using Yourself!Fitness™ (responDESIGN, Portland, OR) for the PlayStation®2 (Sony, Foster City, CA). At the conclusion of exercise, blood pressure was monitored to ensure there was not a rapid decrease in blood pressure using a mercury sphygmomanometer (American Diagnostic Corporation, Hauppauge, NY).

PROCEDURES

Potential participants contacted the investigator via phone or email. At that time they were asked about their age, exercise history and for women, about potential pregnancy (Appendix A). If deemed eligible, participants were given a mutually agreeable time to come to the Applied Physiology Laboratory in Fetzer Gymnasium for a more complete screening and graded exercise test (VO_2max).

When the participant arrived for the screening trial, they were informed of the purpose of the study, procedures involved in the four laboratory visits, risks involved, and benefits of the investigation. Subjects were asked to read and, if agreeable, sign the Informed Consent (Appendix B) and complete a medical history. Completed forms were reviewed, and if the participant was deemed acceptable, they then completed the screening physical examination including a 12-lead resting ECG.

The first trial always consisted of a graded exercise test. Completion of the Yourself!Fitness™ personal profile always occurred during the second trial. The third and fourth trials consisted of the subjects performing either the Weight Loss (WL) or Cardio (CV) workout on the Yourself!Fitness™ video game. The order was presented to the participants randomly. Each subject completed all four trials at the same time of day with at least 24 hours rest between trials. Subjects did not exercise or consume caffeine three hours prior to testing and arrived at the laboratory four hours postprandial.

Trial 1

During the first visit, the study procedures were explained to potential study participants and they were given the opportunity to ask and have their questions answered prior to providing written consent. Once consent has been given, participants completed the medical history, and were given a pre-participation physical exam. After the physical exam, height and weight were measured. Participants then completed a graded exercise test.

Subjects completed the graded exercise test on a treadmill using a protocol that consisted of increases in speed from 3 to 6 miles per hour every 2 minutes. After 8 minutes of exercise, speed was held constant at 6 miles per hour, while grade was increased 5% every 2 minutes until the subject signaled volitional fatigue.

During the graded exercise test, heart rate (HR) was continuously monitored by Polar Heart Rate Monitor and recorded in the last 10 seconds of each stage. The PARVO system was used to measure oxygen uptake (VO_2) during every minute of the test. Rate of perceived exertion (RPE) was measured at the end of every stage. Subjects were monitored at the conclusion of the exercise test until his/her heart rate dropped below120 beats per minute.

The attainment of VO_2peak was determined when two or more of the following criteria were met: 1) a 150 mL/min or less increase, leveling-off, or decrease in VO_2 in response to an increased workload; 2) a heart rate at the age-predicted maximum [within 5-10 bpm]; 3) a respiratory exchange ratio (RER) $\geq$ 1.1; or 4) a rating of perceived exertion (RPE) > 18 (15).

Trial 2

Each subject completed the Yourself!Fitness™ personal profile during their second visit. The first screen of the personal profile required subjects to enter their name (subject ID), gender, and height, in feet and inches. All subjects then indicated that no equipment will be used in the second screen of the personal profile. The subjects then completed the virtual fitness evaluation. During the fitness evaluation, subjects were first requested to enter their weight, in pounds, and resting heart rate. Subjects then completed a two minute jumping jack evaluation following the on-screen animated body model. At the conclusion of the jumping jack evaluation subjects were prompted to enter their exercise heart rate and estimated level of activity over the past six months. Subjects once again, followed the on-screen animated body model to complete body weight squats, pushups, crunches, and sit and reach. Lastly, subjects selected the Yourself!Fitness™ suggested goal focus for their program. The commitment schedule and meal plan aspects of the video game were not taken into consideration for this study; therefore video game defaults were used. To allow for familiarization with the equipment, the Cosmed $K4b^2$ system and heart rate monitor were worn by participants during the trial; however, no data were recorded.

Trials 3 and 4

Each subject performed the Cardio (CV) and Weight Loss (WL) gaming modes of Yourself!Fitness™ (Appendix D and E). The CV and WL gaming modes were randomly assigned for trial three or four. Subjects were also blinded with respect to gaming mode, in that they had no knowledge of the type of activity, either CV or WL, they had performed.

Cardio Gaming Mode (CV)

Prior to the subject's arrival, the researchers set the video game for the CV workout. The video game prompted subjects to respond to the initial perceived exertion question of, "How are you?" Each subject selected, "Not too bad." The CV workout was 30 minutes in length, and included a 3 minute warm-up and a 2 minute cool-down. Maya, the Yourself!Fitness™ virtual personal trainer, lead subjects through the workout. All subjects were given the opportunity to familiarize themselves with the video game prior to testing.

During the CV workout, the Cosmed K4b^2 system was used to measure oxygen uptake (VO_2) and heart rate every minute during the trial. The video game prompted subjects several times throughout the duration of the workout to respond to the perceived exertion question, "How did you feel about that?" Each subject responded, "I was working hard." At the end of the workout, Yourself!Fitness™ reported the calories expended during that exercise session. This value was recorded for further comparison. Heart rate and blood pressure were monitored after the exercise session until the subject reached a heart rate of less than 120 beats per minute (bpm) and/or blood pressure returned to resting levels. At that time, if the participant responded that they were OK, they were released on their own recognizant.

Weight Loss Gaming Mode (WL)

As in the CV trial, Yourself!Fitness™ was set for the WL workout prior to the subject's arrival. The WL workout was 30 minutes in length, and included a 3 minute warm-up and a 2 minute cool-down. Again, Maya, the Yourself!Fitness™ virtual personal trainer, lead subjects through the workout. Perceived exertion prompts prior to and during exercise followed the same format as the CV trial. During the WL trial, VO_2, heart rate, and caloric expenditure were measured and recorded using the same equipment and time intervals as used in the CV trial.

DATA MANAGEMENT

VO_2 and HR measures were averaged minute-by-minute from breath-by-breath readings for the duration of the exercise sessions. This data was used in the analysis of hypothesis 4, 5, and 6. VO_2 and HR measures were further reduced, omitting warm-up and cool-down, for the analysis of hypothesis 1 and 2. The Karvonen formula (%VO_2 (or HR) = ([VO_2exercise – VO_2rest] / [VO_2max – VO_2rest]) x 100) was applied to determine the percentage of max for both VO_2 and HR. This data was analyzed to determine exercise intensity and number of minutes of exercise above the ACSM threshold for the analysis of hypothesis 3.

Descriptive statistics were provided on each of the following subject characteristics: age, height, weight, body mass index, VO_2peak, and HRpeak. For the analysis of hypothesis 1, a paired samples t-test was performed to determine whether there was a significant difference between the mean VO_2 measures for the CV and WL exercise sessions. For the analysis of hypothesis 2, an additional paired samples t-test was performed to compare mean HR measures between the CV and WL exercise sessions. A paired samples t-test was used to

determine statistical significance between the CV and WL exercise sessions for the number of minutes spent above the ACSM threshold for cardiorespiratory fitness (>55% HRpeak or >40% VO_2peak) for the analysis of hypothesis 3. For the analysis of hypothesis 6, a paired samples t-test was used to determine statistical significance between measured energy expenditure between the CV and WL exercise sessions. To determine the ability of the video game to accurately predict energy expenditure, a regression analysis was performed for the analysis of hypothesis 5 and 6. The equation of the line for the CV and WL exercise sessions helped determine whether energy expenditure was over- or under-predicted. The R^2 indicated how closely the predicted and measured energy expenditures were correlated. The alpha level was set at $p < 0.05$ for each statistical analysis.

CHAPTER IV

RESULTS

SUBJECT CHARACTERISTICS

Fifteen participants (8 women and 7 men) aged 18 to 24 years participated in this study. Participants were 172.0 ± 8.2 centimeters (cm) tall, weighed 68.9 ± 11.0 kilograms (kg), and had a body mass index (BMI) of 23.2 ± 2.2. All participants were recreationally active, with self-reported activity levels of at least 30 minutes of recreational activity per day for 3 or more days per week. The mean VO_2peak was 3.8 ± 0.9 L/min or 55.3 ± 8.5 ml/kg/min. The mean maximal heart rate was 195 ± 7.7 beats per minute.

PHYSIOLOGICAL RESPONSES

Oxygen uptake (VO_2) and heart rate (HR) were measured during both the cardio (CV) and weight loss (WL) exercise sessions (Table 1). Omitting warm-up and cool-down, the active portion of each 30 minute exercise bout was approximately 28 minutes for the CV exercise session and approximately 27 minutes for the WL exercise session. A paired samples t-test was performed to determine whether there was a significant difference between the mean VO_2 measures for the CV and WL exercise sessions. Participants were working at an intensity of approximately 43% of their peak absolute and relative oxygen uptake (VO_2peak) for both the CV and WL exercise sessions. There was no significant difference between VO_2 for the CV or WL trials (L/min: $p=0.136$, or mL/kg/min: $p=0.060$). An additional paired samples t-test was performed to compare mean HR measures between

the CV and WL exercise sessions. There was a trend towards significantly higher HR measures during the CV exercise session when compared to the WL exercise session ($p=0.051$), the difference being approximately 5-6 beats per minute. Participants were working at an intensity of approximately 60% of their peak heart rate (HRpeak) for both the CV and WL exercise sessions. The average respiratory exchange ratio (RER) for the CV exercise session was 1.00 ± 0.07, while the WL was 0.99 ± 0.07.

TABLE 1. Oxygen uptake (VO_2) and heart rate (HR) responses during exercise sessions.

Variable	**Cardio (CV)**		**Weight Loss (WL)**	
	Means ± SD	**% Max**	**Means ± SD**	**% Max**
VO_2 (L/min)	1.7 ± 0.4	41.7 ± 8.7	1.8 ± 0.4	44.4 ± 8.1
VO_2 (ml/kg/min)	26.6 ± 4.8	42.3 ± 8.7	23.4 ± 4.8	44.5 ± 8.3
HR (bpm)	141.2 ± 27.4	57.7 ± 18.1	146.8 ± 21.7	61.7 ± 14.8

ACSM GUIDELINES

The ACSM guidelines for developing and maintaining cardiorespiratory fitness were used to assess the CV and WL exercise sessions. Those guidelines recommended a minimum of 40% VO_2max and/or 55% HRmax to improve cardiorespiratory fitness. VO_2 and HR measures were averaged minute-by-minute from breath-by-breath readings and the number of minutes greater than those guidelines are presented in Figure 1. There was no significant difference between time spent above the ACSM threshold for either VO_2 or HR for either the CV or WL trials ($p>0.169$). Participants spent 14-15 minutes above the ACSM threshold during the 30 minute CV exercise session and approximately 16 minutes above the ACSM threshold during the 30 minute WL exercise session.

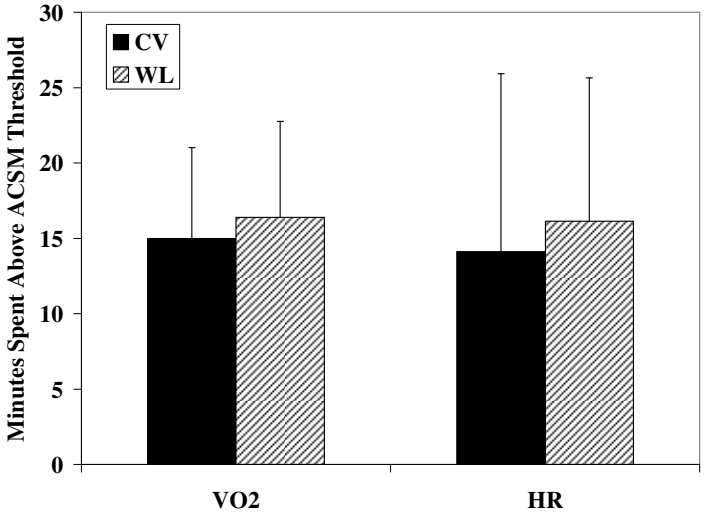

FIGURE 1. Means ± SD for number of minutes spent above ACSM threshold for cardiorespiratory fitness comparing the cardio (CV) and weight loss (WL) exercise sessions. VO_2=oxygen uptake; HR=heart rate.

ENERGY EXPENDITURE

There were no statistically significant differences (p=0.743) between the measured energy expenditure for the CV and WL exercise sessions (CV: 265 ± 61 kcals, WL: 268 ± 60 kcals). However, during the CV exercise session the video game-predicted energy expenditure was 171 ± 34 kcals, while the video game-predicted energy expenditure for the WL exercise session was 162 ± 32 kcals. Based on these findings, a regression analysis was performed to determine the ability of the video game to accurately predict energy expenditure (Figure 2). The equation of the line for the CV exercise session was as follows: kcals = 0.278 (CV predicted kcal) + 96.887, which suggests energy expenditure was under-predicted by approximately 96.9 kilocalories (kcal). The R^2 was 0.252, with a standard error of the estimate (SEE) = 30.4 kcals, and the regression was not statistically significant (p=0.056). The equation of the line for the WL exercise session was as follows: kcals = 0.275 (WL predicted kcal) + 88.002, which suggests energy expenditure was under-predicted

by approximately 88.0 kcal. The R^2 was 0.275, with an SEE = 54.9 kcals, and the regression was statistically significant (p=0.045).

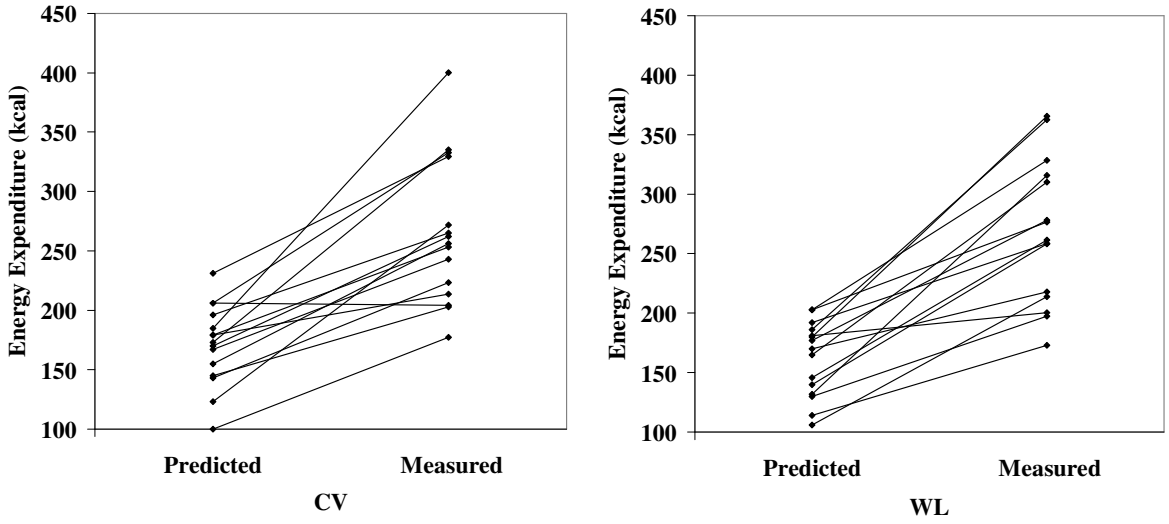

FIGURE 2. Subject-by-subject predicted and measured energy expenditures for the cardio (CV) and weight loss (WL) exercise sessions.

CHAPTER V

DISCUSSION

Widespread societal changes have increased time spent on screen-based activities, such as watching television, playing video games, and using computers (10, 13, 14, 20, 31). In order to offset the common health risks associated with these sedentary behaviors, current physical activity recommendations suggest participation in at least 30 minutes of moderate intensity physical activity on most, preferably all, days of the week (26). The following discussion will explore the results of the use of the Yourself!Fitness™ interactive video game including previous research, pertaining to VO_2 and HR responses, strengths and weaknesses of the video game, limitations of the investigation, conclusions, and recommendations for future research.

"CARDIO" VERSUS "WEIGHT LOSS" EXERCISE SESSIONS

When examining the list of exercise options available on the Yourself!Fitness™ interactive video game, one is lead to believe that participating in the "Cardio" (CV) option should occur at an intensity sufficient to result in improvements in cardiac function and aerobic capacity; while the "Weight Loss" (WL) option should utilize more energy and thus result in a loss of fat mass. Therefore, it follows that the CV and WL exercise sessions should also differ in substrate utilization. The CV exercise session should result in more carbohydrate utilization, while the WL exercise session would generate greater fat utilization. However, the results suggest two exercise options, CV and WL, are actually very similar.

There were no statistically significant differences in VO_2, HR, or measured energy expenditure between the CV and WL exercise sessions. Furthermore, subjective analysis of the respiratory exchange ration (RER) data suggests there were no differences in substrate utilization between the CV and WL exercise sessions. The CV and WL exercise sessions were very similar in the exercises performed, intensity, and duration. The sessions began with 2-3 minutes of dynamic warm-up, followed by approximately 15 minutes of aerobic exercise, approximately 10 minutes of various isometric exercises, and concluded with 1-2 minutes of stretching. Subsequent analysis of RER data indicated that both the CV and WL exercise sessions relied primarily on carbohydrates for energy, indicating a moderate to high level of intensity during exercise.

EXERCISE INTENSITY AND DURATION

The American College of Sports Medicine (ACSM) defines moderate intensity physical activity as 55/65%-90% of maximum heart rate (HRmax) or 40/50%-85% of maximum oxygen uptake (VO_2max) (29). There were no statistically significant differences in the amount of time spent above the ACSM threshold for aerobic training between the CV and WL exercise sessions. Overall, the participants were working at approximately 41-44% of their VO_2peak and 57-62% of their HRpeak for both the CV and WL exercise sessions, indicating that, in general, the exercise intensity was sufficient in meeting the minimum ACSM threshold for developing and maintaining cardiorespiratory endurance. While the mean heart rates and oxygen uptake appear appropriate for aerobic training, the amount of time participants spent at these respective intensities (CV=14-15 min, and WL=~16 min) was well below the recommended guideline of 30 minutes (29).

Although participants did meet the minimum ACSM threshold for both the VO_2 and HR guidelines, most were working at the lower end of the range. There are several explanations why these results may have been seen. The fifteen participants in this investigation were healthy and recreationally active for at least 3 days per week for 30 minutes or longer. Therefore, they may have found the exercise less challenging. Untrained or sedentary participants may have elicited different and potentially higher VO_2 and HR responses, which would result in greater energy expenditures per exercise session. Using only heart rate and a progressive jumping jack test as a guide, the video game-based fitness assessment may not have accurately predicted the aerobic capacity of participants. It is also possible that because ratings of perceived exertion throughout the exercise sessions were standardized, some participants may not have been adequately challenged.

PREDICTED VERSUS MEASURED ENERGY EXPENDITURE

It is not known which algorithm the makers of Yourself!Fitness™ use to predict energy expenditure; however, according to the results of this investigation the predicted energy expenditure is not accurate. Energy expenditure during the CV and WL exercise sessions was under-predicted by approximately 96.9 and 88.0 kilocalories (kcal), respectively. Participants expended approximately 267 kcal during both the CV and WL exercise sessions. Therefore, the energy expenditure during a 30 minute exercise session using Yourself!Fitness™ was similar in magnitude to running for 30 minutes at 11-12 min mile pace, jumping rope at 130 repetitions per minute (rpm), or swimming a slow crawl (17). Although participants were expending enough energy to be similar in intensity to several common physical activities, prolonged use of the Yourself!Fitness™ interactive video game

may not produce an aerobic stimulus sufficient to induce the same cardiorespiratory benefits if only used for a 30 minute exercise session.

POTENTIAL IMPACT

The results of this investigation show there is a potential for cardiovascular benefit through participation in interactive video games. Yourself!Fitness™ may be a good alternative to gym membership when there are monetary or logistic concerns. The portability and ease of use make Yourself!Fitness™ a perfect companion for the stay-at-home mom with no time to make it to the gym, college students living in a dormitory or apartment without access to gym facilities, or any population that would gravitate towards the use of an exercise DVD. This interactive video game can create exercise sessions based on an individual's training status and the fitness equipment they may possess. Use of the Yourself!Fitness™ interactive video game will compliment any established exercise routine.

STRENGTHS AND WEAKNESSES OF THE VIDEO GAME

The Yourself!Fitness™ interactive video game has many features to offer its users. Participants may incorporate their own exercise equipment (i.e. exercise balls, bench steps, free weights, and a heart rate monitor) into their exercise sessions. With the different workout environments and music options, Yourself!Fitness™ is successful in its attempts to stave off boredom. Maya, the virtual personal trainer, is constantly encouraging participants throughout the duration of the exercise session. She also provides reminders about breathing and maintaining proper posture during exercise. Ratings of perceived exertion are used several times throughout the exercise session to ensure participants are being challenged. Other features not directly related to exercise that are available with the Yourself!Fitness™ interactive video game are the meditation garden and meal plan. Participants can participate

in a 30 minute yoga session in the meditation garden. Yourself!Fitness™ offers meal plans for participants who might be looking to monitor caloric intake. These meal plans range from 1200 to 3300 kcals, and include meal ideas as well as ingredients, preparation instructions, and nutritional information for each item. Lastly, investing in Yourself!Fitness™ as a virtual personal trainer provides a cost effective alternative to the higher priced human version. The entire package would cost participants approximately $160 ($130 for the video game console and $30 for the Yourself!Fitness™ video game), while investing in a personal trainer would cost $20-100 per session.

Yourself!Fitness™ claims to have over 500 different exercises available. Within the sessions used for this study, approximately 75 different exercises were seen, but participants were likely to experience approximately 20 different exercises per individual exercise session. When comparing the CV and WL exercise sessions, each session was similar, only differing by 2-3 exercises. Anecdotal information suggests the more you use the video game the greater the variety in exercises available. Because Maya is an on-screen coach, her digital nature makes it hard for her to detect improper form during the execution of various exercises. She cannot provide feedback other than the digital narratives available in the Yourself!Fitness™ database, which make it difficult to add the true personal touch of a traditional personal trainer. Yourself!Fitness™ cannot replace the socialization, instruction, or variety one may experience in a group exercise or gym setting.

LIMITATIONS

One limitation of the current study was the small sample size. The power of the statistical analyses to determine differences in the CV or WL exercise sessions would be increased by a larger sample size. However, since the exercise sessions themselves were

very similar, in terms of exercises used and duration of each exercise, it is the belief of the investigator that no significant differences in VO_2, HR, or energy expenditure between exercise sessions would arise with a larger sample size. All participants were asked to follow certain pre-exercise guidelines to standardize the testing conditions and adherence to these guidelines was self reported. This self-reporting could be a limitation to the current study if all guidelines were not properly followed. If subjects did not consume the same meal prior to the CV or WL exercise sessions their substrate utilization may have differed, which could alter the measured VO_2. However, as previously mentioned, subsequent analysis of RER data indicated there were no differences in substrate utilization between the CV and WL exercise sessions.

Finally, the results of this investigation cannot be generalized to populations outside of apparently healthy, recreationally active 18-24 year-old men and women. It is highly likely that only less active individuals will improve cardiovascular fitness by following the minimum ACSM recommended guidelines of exercising at 40% VO_2max or 55% HRmax. Even the benefits a sedentary individual will gain at these intensities will be limited if regular increases in exercise intensity and duration are not incurred. Despite these limitations, this study is the first to explore physiological responses to participation in this particular video game.

CONCLUSIONS

Interactive video games may help overweight/obese individuals to incorporate physical activity into their daily lives, motivate them to explore other fitness opportunities that may exist, increase the likelihood of adhering to an exercise routine, and provide an alternative to those intimidated by the use of gym facilities. Use of Yourself!Fitness™ and

other interactive video games may lead to increased physical activity opportunities for individuals who do not exercise regularly. However, with little difference in exercises, intensity, or duration, the differences between the CV and WL exercise sessions were difficult to determine. Although the results of this investigation show promise for exercise sessions that are longer in duration, it is also important to remember that exercise is only one component of achieving good health. Interactive video games may motivate individuals to become physically active, but healthy diet and nutritional habits should also be adopted.

Hypothesis 1: There will be no statistically significant difference in oxygen uptake (VO_2) between the Cardio and Weight Loss exercise sessions. This hypothesis was *accepted*.

Hypothesis 2: There will be no statistically significant difference in heart rate between the Cardio and Weight Loss exercise sessions. This hypothesis was *accepted*.

Hypothesis 3: There will be no statistically significant difference between the amount of time spent above the ACSM threshold for aerobic training (greater than 40% VO_2max or 55% HRmax) between the Cardio and Weight Loss modes. This hypothesis was *accepted*.

Hypothesis 4: There will be no relationship between the game-predicted and measured energy expended, in kilocalories, for the duration of the Cardio mode. This hypothesis was *accepted*.

Hypothesis 5: There will be no relationship between the game-predicted and measured energy expended, in kcals, for the duration of the Weight Loss mode. This hypothesis was *partially accepted* because the game-predicted and measured

energy expended were statistically correlated (r^2=0.275, p=0.045), but energy expenditure was under-predicted by 88 kcal.

Hypothesis 6: There will be no statistically significant difference in the measured energy expended, in kcals, between the Cardio and Weight Loss modes. This hypothesis was *accepted*.

RECOMMENDATIONS

Further research is needed to determine if participation in Yourself!Fitness™ on a regular basis over several weeks can improve the cardiorespiratory fitness of participants; a training study. Researchers should investigate the changes in physiological parameters with prolonged used of Yourself!Fitness™ as a regular exercise routine. The exercise duration of future studies should be increased to 60 minutes in an attempt to achieve VO_2 and HR measures above the ACSM threshold. It is also suggested that the fitness equipment option be used. Participants may use free weights, step benches, exercise balls, or heart rate monitors during the exercise sessions, which may elicit greater energy expenditures. When using the heart rate monitor during the exercise sessions a heart rate range is displayed on-screen so participants can monitor and adjust the intensity of their workout accordingly. Participants should also be given the ability to control their "rate of perceived exertion" to enhance the customization of an exercise session.

LIST OF APPENDICES

APPENDIX

A. Pre-Enrollment Interview Script via Phone or Email 35

B. Informed Consent.....36

C. Data Collection Forms 42

D. Sample 30 Minute “Cardio” Exercise Session.....45

E. Sample 30 Minute “Weight Loss” Exercise Session 46

APPENDIX A

Pre-Enrollment Interview Script via Phone or Email

Hello, how are you? My name is Brittany Yates. I am conducting research for my Master's Thesis on the energy cost of a new interactive video game. The study will take about 4 hours, in four separate sessions (Session 1 will last approximately 90 minutes and Sessions 2-4 will last approximately 45 minutes), over a three week period, and involve measuring your maximal exercise capacity, and then measuring your energy expenditure during different phases of the video game. Would you be interested in participating?

NO, Thank you for contacting me. Good bye.
YES, That is great! Now, I have three questions for you to ensure you qualify for participation in this study.

1. Are you between the ages 18 and 24?
   YES, proceed to question 2
   NO, thank you for your interest, but you are not eligible for participation in this study

2. Do you regularly participate in physical activity – 3 or more days a week for 30 minutes or longer each session?
   Yes, for men, proceed to scheduling an appointment to sign consent forms and health screening
   Yes, for women, proceed to question 3
   No, thank you for your interest, but you are not eligible for participation in this study

3. For women: Are you pregnant, or planning to become pregnant in the next month?
   No, proceed to scheduling an appointment to sign consent forms and health screening
   Yes, thank you for your interest, but you are not eligible for participation in this study

APPENDIX B
Informed Consent

University of North Carolina-Chapel Hill
Consent to Participate in a Research Study
Adult Subjects
Biomedical Form

IRB Study #07-1859
Consent Form Version Date: 11/07/2007

Title of Study: A Pilot Study on Energy Expenditure and Interactive Video Game Play

Principal Investigator: Brittany E. Yates
UNC-Chapel Hill Department: Exercise and Sport Science
UNC-Chapel Hill Phone number: (757) 439-0893
Email Address: yatesbe@email.unc.edu
Faculty Advisor: Robert G. McMurray, Ph.D.
Funding Source: None

Study Contact telephone number: (757) 439-0893
Study Contact email: yatesbe@email.unc.edu

What are some general things you should know about research studies?
You are being asked to take part in a research study. To join the study is voluntary. You may refuse to join, or you may withdraw your consent to be in the study, for any reason.

Research studies are designed to obtain new knowledge that may help other people in the future. You may not receive any direct benefit from being in the research study. There also may be risks to being in research studies.

Deciding not to be in the study or leaving the study before it is done will not affect your relationship with the researcher, your health care provider, or the University of North Carolina-Chapel Hill. If you are a patient with an illness, you do not have to be in the research study in order to receive health care.

Details about this study are discussed below. It is important that you understand this information so that you can make an informed choice about being in this research study. You will be given a copy of this consent form. You should ask the researchers named above, or staff members who may assist them, any questions you have about this study at any time.

What is the purpose of this study?
Interactive video games have the potential to increase physical activity levels, which could result in the reduction of cardiovascular disease risk factors and also promote weight loss. However, we know nothing about the energy expenditure to the game, Yourself!Fitness™.

The purpose of this investigation is to determine the energy expenditure and heart rate responses to participation in the "Yourself!Fitness™," interactive fitness video game. Of particular interest, this study will investigate differences in the manufacturer's game-predicted and measured caloric expenditure for both the Cardio and Weight Loss gaming modes. Additional comparisons will be made for caloric expenditure between the Cardio and Weight Loss modes between college age males and females.

Research in this area is significant because obesity is on the rise. Therefore, it is of paramount importance to explore other venues for promoting physical exercise. Activity-promoting video games could become potent tools for weight management and potentially reversing sedentary behaviors while permitting highly valued screen-based activities. It has not yet been determined, whether Yourself!Fitness™ is effective in increasing energy expenditure equivalent to moderate and/or vigorous intensity physical activity. The knowledge gained through research using Yourself!Fitness™ will help exercise physiologists determine if video game play can be a viable means for physical activity.

You are being asked to be in the study because you are between the ages of 18 and 24 and are physically active 3 or more days a week for 30 minutes or longer during each session.

Are there any reasons you should not be in this study?
You should not be in this study if you have a history of heart disease, uncontrolled diabetes, hypertension, pulmonary disease, severe arthritis, extreme overweight, pregnancy, major orthopedic maladies, or any other condition that could place you at risk during exercise.

For Females Only: If you are currently pregnant, or become pregnant during the study, you should not participate in this study because the exercise intensity and duration may be greater than what is recommended by the American College of Obstetricians and Gynecologists (ACOG).

How many people will take part in this study?
If you decide to be in this study, you will be one of approximately 20 people in this research study.

How long will your part in this study last?
You will participate in a total of 4 testing sessions. The initial testing session will be no longer than 90 minutes, while the remaining sessions will last no more than 1 hour. Each participant will complete all four trials within 3 weeks of beginning the study so that changes in training status do not become a factor. You will complete all four trials at the same time of day with at least 24 hours rest between trials.

What will happen if you take part in the study?

Trial 1

During the first visit, the study procedures will be explained to you and you will be given the opportunity to ask and have your questions answered prior to providing written consent. Once consent has been given, you will complete the medical history, and be given a pre-participation physical exam. After the physical exam, height and weight will be measured. You will then complete a graded exercise test at this time.

The graded exercise test will be completed on a treadmill using a modified using a protocol that consists of increases in speed from 3 to 6 miles per hour every 2 minutes. After 8 minutes of exercise, speed was held constant at 6 miles per hour, while grade was increased 5% every 2 minutes until the subject signaled volitional fatigue. Heart rate will be continuously monitored by hear rate monitor and recorded in the last 10 seconds of each stage. A breathing valve with nose clips will be used to measure metabolic rate during every minute of the test. Rate of perceived exertion (RPE) will be measured at the end of every stage. You will be monitored at the conclusion of the exercise test until heart rate reaches 120 beats per minute or less.

Trial 2

You will complete the Yourself!Fitness™ personal profile during your second visit. A portable system that measures metabolic rate and a heart rate sensing chest strap will be worn during this session to allow for familiarization, however no data will be recorded. The first screen of the personal profile requires you to enter your "name," in the form of the subject ID number, gender, and height. You will then indicate that no equipment will be used in the second screen of the personal profile. You will then complete the virtual fitness evaluation.

During the fitness evaluation, you are first requested to enter your weight. The video game will then instruct you how to measure and record your resting heart rate. Next, you will complete a two minute jumping jack evaluation following the on-screen animated body model. At the conclusion of the jumping jack evaluation the video game will once again prompt you to measure and record your exercise heart rate. You will also indicate your current level of activity over the past six months. You will once again, follow the on-screen animated body model to complete body weight squats, pushups, crunches, and sit and reach. Lastly, you will select the Yourself!Fitness™ suggested goal focus for their program. The commitment schedule and meal plan aspects of the video game will not be taken into consideration for this study; therefore game defaults will be used.

Trials 3 and 4

You will perform the Weight Loss (WL) or Cardio (CV) gaming modes of Yourself!Fitness™. The modes will be randomly assigned for the next two trials. You will also be blinded with respect to gaming mode, in that you will receive no knowledge of the WL or CV mode you will perform for each trial. You should not exercise or consume caffeine three hours prior to testing and arrive at the laboratory no sooner than four hours after eating.

Weight Loss Gaming Mode (WL)
The video game will prompt you to respond to the initial perceived exertion question of, "How are you?" You will select "Not too bad." The WL workout will be 30 minutes in length including a 3 minute warm-up and a 2 minute cool-down. Maya, the Yourself!Fitness™ virtual personal trainer, will lead you through the workout.

During the WL workout, the portable metabolic system and heart rate sensing chest strap will be continuously worn throughout the duration of the exercise bout. The system will be used to measure respiratory gases and heart rate every minute during the trial. The video game will prompt you several times throughout the duration of the workout to respond to the perceived exertion question, "How did you feel about that?" You will respond, "I was working hard." Yourself!Fitness™ will report the calories expended during that exercise session at the end of the workout. This value will be recorded for further comparison. Heart rate and blood pressure will be monitored after the exercise bout until your heart rate is less than 120 beats per minute (bpm) and/or your blood pressure returns to resting levels. At that time, if you respond that you are OK, the person will be released on their own recognizant.

Cardio Gaming Mode (CV)
The CV workout will be 30 minutes in length including a 3 minute warm-up and a 2 minute cool-down. Again, Maya, the Yourself!Fitness™ virtual personal trainer, will lead you through the workout. Perceived exertion prompts prior to exercise and during will follow the same format as the WL trial. Measurements during the CV trial will be recorded using the same equipment and time intervals as used in the WL trial.

Please note that some individuals may not be eligible for participation based on the outcome of baseline testing (i.e. medical history, physical exam, or EKG). If it is determined that you will not be eligible for participation in this study due to findings during baseline testing you will be referred to your primary care physician, Student Health, or in extreme cases, UNC Hospitals.

What are the possible benefits from being in this study?
Research is designed to benefit society by gaining new knowledge. You will benefit from participation in this study in that you will learn your cardiorespiratory fitness (VO_2max) and you may also obtain a copy of your pre-test electrocardiogram (EKG).

What are the possible risks or discomforts involved with being in this study?
There should be no risk of psychosocial harm, economic harm, or legal jeopardy. Medications will not be used in this study; therefore, there is no risk of drug-related side-effects.

There are risks associated with participation in this study, such as: fatigue, muscle soreness, sprain, strain, and/or broken bones. These are minimal, but do exist. Risks are minimized by proper warm-up and cool-down as well as continuous prompting by the video game to ensure exercise intensity is appropriate. It is unlikely, but you may experience chest pain, dizziness, fainting, abnormal heart rhythms or even a heart attack. Although rare, sudden death has been reported during strenuous exercise, even in highly trained athletes.

Although no radioactive materials are being used for this study, the UNC Chapel Hill Applied Physiology Laboratory, where you will be performing exercise tests, houses radioactive materials. The amount of radioactive material is very small and should pose no health threat to subjects. All radioactive material is stored in a contained biochemistry section of the Applied Physiology Laboratory, and is kept in compliance with all UNC Office of Environmental, Health & Safety regulations.

In addition, there may be uncommon or previously unknown risks that might occur. You should report any problems to the researchers.

What are the risks to a pregnancy or to a nursing child?

If you are a woman and you are planning to get pregnant, you should not be in the study. The exercise intensity and duration of exercise in this study may be greater than what is recommended by the American College of Obstetricians and Gynecologists (ACOG).

How will your privacy be protected?

No subjects will be identified in any report or publication about this study. Although every effort will be made to keep research records private, there may be times when federal or state law requires the disclosure of such records, including personal information. This is very unlikely, but if disclosure is ever required, UNC-Chapel Hill will take steps allowable by law to protect the privacy of personal information. In some cases, your information in this research study could be reviewed by representatives of the University, research sponsors, or government agencies for purposes such as quality control or safety.

Upon agreement to participate in the study, you will receive a participation number, and be referred to by that number at all times during the study. Any electronic files containing information linking subjects to their respective participation number will be in a password protected document on a password protected computer. Only my faculty adviser and I will have access to this information. Data collected throughout the duration of the study will be stored in a locked file cabinet in the Applied Physiology Lab. Once you have participation in the study, all information linking you to participation in this study will be destroyed.

What will happen if you are injured by this research?

All research involves a chance that something bad might happen to you. This may include the risk of personal injury. In spite of all safety measures, you might develop a reaction or injury from being in this study. If such problems occur, the researchers will help you get medical care, but any costs for the medical care will be billed to you and/or your insurance company. The University of North Carolina at Chapel Hill has not set aside funds to pay you for any such reactions or injuries, or for the related medical care. However, by signing this form, you do not give up any of your legal rights.

What if you want to stop before your part in the study is complete?

You can withdraw from this study at any time, without penalty. The investigators also have the right to stop your participation at any time. This could be because you have had an unexpected reaction, or have failed to follow instructions, or because the entire study has been stopped.

Will you receive anything for being in this study?
You will be receiving data on your cardiorespiratory fitness (VO_2max) and a copy of your pre-test electrocardiogram (EKG) for taking part in this study.

Will it cost you anything to be in this study?
It will not cost you anything to participate in this study. You will be responsible for paying for transportation and parking costs, if necessary.

What if you are a UNC student?
You may choose not to be in the study or to stop being in the study before it is over at any time. This will not affect your class standing or grades at UNC-Chapel Hill. You will not be offered or receive any special consideration if you take part in this research.

What if you are a UNC employee?
Taking part in this research is not a part of your University duties, and refusing will not affect your job. You will not be offered or receive any special job-related consideration if you take part in this research.

Who is sponsoring this study?
This research is not funded by any outside resources.

What if you have questions about this study?
You have the right to ask, and have answered, any questions you may have about this research. If you have questions, or if a research-related injury occurs, you should contact the researchers listed on the first page of this form.

What if you have questions about your rights as a research subject?
All research on human volunteers is reviewed by a committee that works to protect your rights and welfare. If you have questions or concerns about your rights as a research subject you may contact, anonymously if you wish, the Institutional Review Board at 919-966-3113 or by email to IRB_subjects@unc.edu.

- -

Subject's Agreement:
I have read the information provided above. I have asked all the questions I have at this time. I voluntarily agree to participate in this research study.

_____ _____
Signature of Research Subject Date

Printed Name of Research Subject

_____ _____
Signature of Person Obtaining Consent Date

Printed Name of Person Obtaining Consent

APPENDIX C
Data Collection Forms

Energy Expenditure and Video Games **Subject _____**

Trial 1 Date:_____ Time:_____

Prior to Subject Arrival:

- **Turn PARVO on 45 min early –** Time:_____
  - 3-5 PSI → bleed system and toggle if not
  - Gas Calibrate → change variables should be <1%
  - Flowmeter Calibration →1st flow rate <80L/min 5th >400L/min→% error <3%
- Set up Mouthpiece, Headgear & Noseclips
- Set up EKG

Subject Arrives:

- **Informed Consent**
  - Ask if any Questions?
  - Sign
- **Medical History**
- **Meal Last Eaten** _____
  - Time (4hrs ago?) _____
- **Caffeine last 3 hours** **Y** **N**
- **Exercise last 3 hours** **Y** **N**
- **12-Lead EKG**
- **Physical Screening**
  - BP _____
  - Resting HR _____
- **Height** _____cm _____in
- **Weight** _____kg _____lbs
- **Graded Exercise Test**

Time (min)	Speed (mph)	Grade (%)	HR (bpm) last 10 sec	RPE end of stage
0-2	**FLUSH**			
2-4	3	0		
4-6	4	0		
6-8	5	0		
8-10	6	0		
10-12	6	5		
12-14	6	10		
14-16	6	15		
16-18	6	20		
18-20	6	25		

- **Post Test - Monitor HR & BP**
  - HR < 120 bpm
- **VO_2peak** (2 or more of the following)
  - 150 mL/min or less increase, leveling-off, or decrease in VO_2 in response to an ↑ workload
  - heart rate at the age-predicted maximum [within 5-10 bpm]
  - respiratory exchange ratio (RER) ≥ 1.1
  - rating of perceived exertion (RPE) > 18
- **VO_2peak_____ HRpeak_____ RERpeak_____ Test Duration_____**

Energy Expenditure and Video Games **Subject _____**

Trial 2 Date:_____ Time:_____

Prior to Subject Arrival:

- **Set up Cosmed**

Subject Arrives:

- Pregnant? **Y** **N**
- Meal Last Eaten _____ Time (4hrs ago?) _____
- Caffeine last 3 hours **Y** **N**
- Exercise last 3 hours **Y** **N**
- **Height** _____cm _____in
- **Weight** _____kg _____lbs
- **Workout Options**
  - Music **Hip-Hop** **80s** **Latin**
  - Environment **Urban Oasis** **Emperor's Dojo**
- **Fit to Cosmed**
- **Vital Statistics**
  - Participant ID
  - Gender _____
  - Height _____
  - Date of Birth _____
- **Fitness Evaluation**
  - Weight _____
  - Resting Heart Rate (10 second count) _____
  - 2 Minute Jumping Jack Evaluation following the animated body model (ABM)
  - Exercise Heart Rate (10 second count) _____
  - Activity Level Past 6 Months **Sedentary** **Moderate** **Active**
  - Body Weight Squats _____
  - Pushups _____
  - Crunches _____
  - Sit and Reach (Poor **1** **2** **3** **4** **5** **6** **7** **8** **9** **10** Excellent)
  - Recommended Fitness Goal **WL** **CV** **UB** **CB** **LB** **Flex**

Energy Expenditure and Video Games **Subject _____**

Trial 3 Date:_____ Time:_____

Prior to Subject Arrival:

- **Turn on Cosmed on 45 min early** Time:_____
- **Calibrate Cosmed**
- Set Yourself!Fitness™ **WL** **CV**
  - Music **Hip Hop** **80s** **Latin**
  - Environment **Urban Oasis** **Emperor's Dojo**

Subject Arrives:

- Pregnant? **Y** **N**
- Meal Last Eaten _____ Time (4hrs ago?) _____
- Caffeine last 3 hours **Y** **N**
- Exercise last 3 hours **Y** **N**
- Height _____cm _____in
- Weight _____kg _____lbs
- Fit to Cosmed
- Begin 30 minute workout
- Calories Burned _____

Trial 4 Date:_____ Time:_____

Prior to Subject Arrival:

- **Turn on Cosmed on 45 min early** Time:_____
- **Calibrate Cosmed**
- Set Yourself!Fitness™ **WL** **CV**
  - Music **Hip Hop** **80s** **Latin**
  - Environment **Urban Oasis** **Emperor's Dojo**

Subject Arrives:

- Pregnant? **Y** **N**
- Meal Last Eaten _____ Time (4hrs ago?) _____
- Caffeine last 3 hours **Y** **N**
- Exercise last 3 hours **Y** **N**
- Height _____cm _____in
- Weight _____kg _____lbs
- Fit to Cosmed
- Begin 30 minute workout
- Calories Burned _____

APPENDIX D

Sample 30 Minute "Cardio" Exercise Session

Duration (min:sec)	Activity	Difficulty (1-5)
0:15	Step Touch Warm-up	1
0:30	March Warm-up	1
0:15	Side Kick Warm-up	1
0:30	Kick Warm-up	1
0:30	March Warm-up	1
0:15	Side Kick Warm-up	1
0:15	Step Touch Warm-up	1
0:30	March Warm-up	1
1:00	Fast Step Ups	4
0:30	Skip Up and Back	3
0:30	Side Kick	1
0:15	Kick	1
0:30	Step Touch	1
0:30	Fast Step Ups	4
1:00	Knee Ups	4
1:00	Step Touch	1
0:30	Turn Step	1
0:15	Frog Leaps	5
0:15	Karate Kick Squat R	4
0:15	Karate Kick Squat L	4
1:00	Knee Ups	4
0:15	Kick	1
0:30	Side Kick	1
0:30	V Step	1
0:30	Shuffles	4
0:08	Rest	0
0:07	Jog In Place	3
0:30	Side Kick	1
0:15	Jog In Place	3
0:08	Rest	0
0:07	Jumping Jacks	3
0:15	Squat Jacks	3
0:30	Double Heel Jacks	3
0:15	Double Jacks	5
0:15	Jumping Jacks	3
0:15	Water	0
0:15	Frog Leaps	5
1:00	Knee Ups	4
1:00	Step Touch	1
1:00	Fast Step Ups	4
0:15	Karate Kick Squat L	4
0:15	Karate Kick Squat R	4
1:00	Step Touch	1
0:30	Turn Step	1
0:08	Rest	0
0:07	Jumping Jacks	3
0:30	Double Heel Jacks	3

How did you feel about that?

0:30	Reverse Lunge R (8 Reps)	2
0:20	Rest	0
0:30	Reverse Lunge L (8 Reps)	2
0:20	Rest	0
0:15	Kneeling Donkey Ext. Pulse	1
0:20	Rest	0
0:30	Reverse Lunge R (8 Reps)	2
0:20	Rest	0
0:30	Reverse Lunge L (8 Reps)	2
0:20	Rest	0

How did you feel about that?

0:30	Squat Lunge R (8 reps)	2
0:15	Rest	0
0:30	Squat Lunge L (8 reps)	2
0:15	Rest	0
0:30	Squat Lunge R (8 reps)	2
0:15	Rest	0
0:30	Squat Lunge L (8 reps)	2
0:15	Rest	0

How did you feel about that?

0:15	Quad Stretch L.	1
0:15	Quad Stretch R.	1
0:15	Hamstring Stretch L.	1
0:15	Hamstring Stretch R.	1

Warm Up

Cool Down

APPENDIX E

Sample 30 Minute "Weight Loss" Exercise Session

Duration (min:sec)	Activity	Difficulty (1-5)
0:15	Side Kick Warm-up	1
0:30	March Warm-up	1
0:30	Kick Warm-up	1
0:15	Step Touch Warm-up	1
0:15	Side Kick Warm-up	1
0:30	Kick Warm-up	1
0:30	March Warm-up	1
0:15	Side Kick Warm-up	1
1:00	Out out in in	3
1:00	Cross Country	4
0:30	Step Touch	1
0:30	V Step	1
0:30	Turn Step	1
0:30	Side Kick	1
1:00	Fast Step Ups	4
0:15	Karate Kick Squat R	4
0:15	Karate Kick Squat R	4
0:30	Skip Up and Back	3
0:30	Side Kick	1
0:30	Step Touch	1
0:15	Kick	1
0:30	Cross Country	4
1:00	Fast Step Ups	4
0:15	Karate Kick Squat L	4
0:15	Karate Kick Squat R	4
0:30	Turn Step	1
0:30	V Step	1
0:30	Turn Step	1
0:30	Shuffles	4
0:15	Karate Kick Squat L	4
0:15	Karate Kick Squat R	4
0:08	Rest	0
0:07	Jog In Place	3
0:30	Hops	3
0:15	Jog In Place	3
0:08	Rest	0
0:07	Jumping Jacks	3
0:15	Double Jacks	5
0:30	Jumping Jacks	3
0:15	Water	0
0:15	Karate Kick Squat L	4
0:15	Karate Kick Squat R	4
0:15	Frog Leaps	5
0:30	V Step	1
0:15	Double Squats	3
1:00	Step Touch	1

Warm Up

Duration (min:sec)	Activity	Difficulty (1-5)
0:15	Karate Kick Squat L	4
0:15	Karate Kick Squat R	4
0:30	Fast Step Ups	4
0:30	Knee Ups	4
1:00	Step Touch	1
0:15	Kick	1
0:08	Rest	0
0:07	Jog In Place	3
0:30	Kick	1
0:15	Jog In Place	3
0:08	Rest	0
0:07	Jumping Jacks	3
0:15	Double Jacks	5
How did you feel about that?		
0:30	Squat Lunge R (8 reps)	2
0:15	Rest	0
0:30	Squat Lunge L (8 reps)	2
0:15	Rest	0
0:30	Squat Lunge R (8 reps)	2
0:15	Rest	0
0:30	Squat Lunge L (8 reps)	2
0:15	Rest	0
How did you feel about that?		
0:30	Plie Front Raise (8 reps)	1
0:20	Rest	0
0:30	Plie Front Raise (8 reps)	1
0:20	Rest	0
How did you feel about that?		
0:30	One Leg Plank	3
0:20	Rest	0
0:30	One Leg Plank	3
0:20	Rest	0
How did you feel about that?		
0:15	Quad Stretch L.	1
0:15	Quad Stretch R.	1
0:15	Hamstring Stretch L.	1
0:15	Hamstring Stretch R.	1

Cool Down

REFERENCES

1. Anders M. Human Joysticks. *ACE FitnessMatters* 13: 5: 7-9, 2007.

2. Anonymous. Let's get physical [Online]. DailyCandy, Inc. http://www.dailycandy.com/everywhere/article/22023/Lets+Get+Physical;jsessionid=D6A7F0A8017E71D71CD0E0FCB086E268 [03/12 2007].

3. Anonymous. Yourself!Fitness™ [Online]. responDESIGN. http://www.yourselffitness.com/ [03/27 2007].

4. Centers for Disease Control and Prevention (CDC). Prevalence of regular physical activity among adults--United States, 2001 and 2005. *MMWR Morb Mortal Wkly Rep* 56: 46: 1209-1212, 2007.

5. Covey N. The State of the Console: Video Game Console Usage [Online]. Wireless and Interactive Services - The Nielsen Company. http://www.nielsenmedia.com/nc/nmr_static/docs/Nielsen_Report_State_Console_03507.pdf [6/27 2007].

6. Davenport M. Cyber sweat [Online]. Chicago Sun-Times. http://www.suntimes.com/output/lifestyles/cst-ftr-game29.html [11/08 2007].

7. Dietz WH, Bandini LG, Morelli JA, Peers KF, Ching PL. Effect of sedentary activities on resting metabolic rate. *Am J Clin Nutr* 59: 3: 556-559, 1994.

8. Duffield R, Dawson B, Pinnington HC, Wong P. Accuracy and reliability of a Cosmed K4b2 portable gas analysis system. *J Sci Med Sport* 7: 1: 11-22, 2004.

9. Entertainment Software Association. Essential facts about the computer and video game industry [Online]. Entertainment Software Association http://www.theesa.com/facts/pdfs/ESA_EF_2007.pdf [01/08 2008].

10. Gortmaker SL, Must A, Sobol AM, Peterson K, Colditz GA, Dietz WH. Television viewing as a cause of increasing obesity among children in the United States, 1986-1990. *Arch Pediatr Adolesc Med* 150: 4: 356-362, 1996.

11. Hausswirth C, Bigard AX, Le Chevalier JM. The Cosmed K4 telemetry system as an accurate device for oxygen uptake measurements during exercise. *Int J Sports Med* 18: 6: 449-453, 1997.

12. Hobbs E. Playing video games while working out [Online]. The Baltimore Sun. http://www.yourselffitness.com/pdf/BaltimoreSun120304.pdf [11/08 2007].

13. Janz K, Mahoney L. Maturation, gender, and video game playing are related to physical activity intensity in adolescents: the Muscatine study. *Pediatr Exerc Sci* 9: 353-363, 1997.

14. Lanningham-Foster L, Jensen TB, Foster RC, Redmond AB, Walker BA, Heinz D, Levine JA. Energy expenditure of sedentary screen time compared with active screen time for children. *Pediatrics* 118: 6: e1831-1835, 2006.

15. MacDougall JD, Wenger HA, Green HJ. *Physiological testing of the high-performance athlete.* Champaign, Ill.: Human Kinetics, 1991, p. 432.

16. Maddison R. Energy Expended Playing Video Console Games: An Opportunity to Increase Children's Physical Activity? *Pediatr Exerc Sci* 19: 3: 334-344, 2007.

17. McArdle WD, Katch FI, Katch VL. *Exercise physiology: energy, nutrition, and human performance.* Philadelphia: Lea & Febiger, 1991, p. 853.

18. McLaughlin JE, King GA, Howley ET, Bassett DR, Jr, Ainsworth BE. Validation of the COSMED $K4b^2$ portable metabolic system. *Int J Sports Med* 22: 4: 280-284, 2001.

19. National Institute of Health. Physical activity and cardiovascular health. *NIH Consens Statement* 13: 3: 1-33, 1995.

20. Ni Mhurchu C, Maddison R, Jiang Y, Jull A, Prapavessis H, Rodgers A. Couch potatoes to jumping beans: A pilot study of the effect of active video games on physical activity in children. *Int J Behav Nutr Phys Act* 5: 8-13, 2008.

21. Nintendo. Wii Fit [Online]. Nintendo. http://www.nintendo.com/wiifit/launch/?ref= [12/16 2007].

22. Norlin A. Exercise Intensity of Dance Dance Revolution [Abstract]. J Cardiopulm Rehabil Prev 27: 5: 331, 2007.

23. Ogden CL. Prevalence of Overweight and Obesity in the United States, 1999-2004. *JAMA* 295: 13: 1549, 2006.

24. Ortutay B. Nintendo tops videogame sales in 2007 [Online]. Associated Press. http://www.msnbc.msn.com/id/22718374/from/ET [01/20 2008].

25. Parker JR. Human Motion as Input and Control in Kinetic Games [Online]. University of Calgary. http://www.ucalgary.ca/~jparker/cs70103/KineticGames.pdf [1/15 2008].

26. Pate RR, Pratt M, Blair SN, Haskell WL, Macera CA, Bouchard C, Buchner D, Ettinger W, Heath GW, King AC. Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA* 273: 5: 402-407, 1995.

27. Pelfrey D. Yourself!Fitness™ [Online]. Digital Entertainment News. http://www.dignews.com/review.php?story_id=6639 [05/23 2007].

28. Pleis JR, Lethbridge-Cejku M. Summary health statistics for U.S. adults: National Health Interview Survey, 2006. *Vital Health Stat 10* (235): 235: 1-163, 2007.

29. Pollock ML, Gaesser GA, Butcher JD, Després JP, Dishman RK, Franklin BA, Garber CE. American College of Sports Medicine Position Stand. The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. *Med Sci Sports Exerc* 30: 6: 975-991, 1998.

30. responDesign. Let's Exercise with G-Cluster (Press Release) [Online]. responDesign, Inc. http://respondesign.com/images/pressroom/RDI_CiT_release092007a.pdf [1/16 2008].

31. Ridley K, Olds T. Video Center Games: Energy Cost and Children's Behaviors. *Pediatr Exerc Sci* 13: 413-421, 2001.

32. Segal KR, Dietz WH. Physiologic responses to playing a video game. *Am J Dis Child* 145: 9: 1034-1036, 1991.

33. Smith BK. Physical Fitness in Virtual Worlds. *Computer* 38: 101, 2005.

34. Tan B, Aziz AR, Chua K, Teh KC. Aerobic demands of the dance simulation game. *Int J Sports Med* 23: 2: 125-129, 2002.

35. United States Department of Health and Human Services. *Physical Activity and Health: A Report of the Surgeon General*. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, 1996, p. 278.

36. Unnithan VB. Evaluation of the Energy Cost of Playing a Dance Simulation Video Game in Overweight and Non-Overweight Children and Adolescents. *Int J Sports Med* 27: 10: 804-809, 2006.

37. Warburton DER. The Health Benefits of Interactive Video Game Exercise. *Can J Appl Physiol* 30: S84, 2005.

38. Yourself!Fitness™. Yourself!Fitness™ Forum [Online]. responDESIGN. http://forum.yourselffitness.com/ [03/27 2007].